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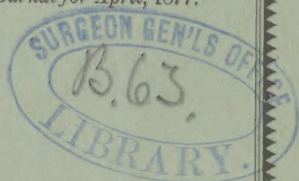
HISTORY
OF THE
DISCOVERY
OF THE
CIRCULATION OF THE BLOOD.

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DISCOVERY OF THE CIRCULATION OF THE BLOOD.

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On a beautiful Sunday afternoon in the fall of 1642 was fought the battle of Edgehill, so memorable in English history. The scene on that October evening was a remarkable one, and has a peculiar interest for us as physicians, aside from its influence on the civil liberties of England.

In the foreground lies the little town of Keinton, while in the distance is seen the vast expanse of woody Warwickshire, already resplendent in its autumnal coloring.

King Charles the First, with his handsome, melancholy face reflecting the fitful gleams which fortune sends over the royal arms, is there as the central figure. A little to one side, sheltered by a hedge, is seen a group of three, whose employment contrasts strangely with the warlike nature of their surroundings. Let us draw nearer to this group.

Reclining on the ground, deeply absorbed in reading a book, is a man of the lowest stature, olivaster complexion, a black, piercing eye, whose hoary locks tell the story of more than three score years. Around him are two children familiarly playing, now interrupting his studies with some childish question, and again watching the ebb and flow of the battle in the near distance.

The elderly man is Dr. William Harvey, physician to the royal family. The children are the young Prince and Duke

of York, afterwards Charles II. and James II. Soon a bullet from a great gun plows the ground near them, which causes the aged physician to close his book and remove his royal charges to a safer location.

We have chosen this moment to introduce to you Dr. Harvey, the illustrious discoverer of the circulation of the blood, not because the battle-field or his connection with royalty add any thing to his glory or prominently reflect his character. We have chosen it rather because the coolness, the courage, the force of character, and the entire consecration to his work which would lead him to prosecute his studies with the fight going on around him, *are characteristic* of the man.

We can not attribute Harvey's behavior on this occasion to indifference to the fortunes of his patron and king, for while we scarcely expect to find him in full sympathy with the effort to overthrow parliament and English Puritanism, yet King Charles had been his friend and protector.

Vacillating and repulsive as is the character of Charles in many respects, when we look upon him as the friend of science, as the patron of a Van Dyke and a Rubens, and see him in the laboratory, sitting an enthusiastic disciple at the feet of the "crack-brained circulator," as Harvey was jealously nick-named, going over, step by step, the proofs of the new theory, we find abundant reason for Harvey's adherence to his person.

Having just completed our study of the blood and the mechanism by which it is enabled to run its fertilizing course throughout the organism, it will be both interesting and profitable for us to go briefly over the history of the discovery of the circulation of the blood. This history possesses more than ordinary interest now, both from the nearness of Harvey's tercentenary (1878), at which a proper memorial will be placed in Folkstone, his birth-place, and from the numerous impeachments to Harvey's title as discoverer which have been recently published.

These, however, are mostly revivals of the same claims of which Haller long ago said: "Others at length, that could not withstand their own eyes and the just sentence of all Europe in its favor, were invidiously for depriving our British Hippocrates, who pulled off the blind-fold from physic, of the honors due from so great discoveries, by fishing them out from the dark waters of his predecessors."

A late memoir (1876) by Henri Tollin, of Magdeburg, brings to the surface once more the oft-repeated claims of Michael Servetus, one of the most remarkable men of his day, and whose tragic fate always awakens our deepest sympathies. A memorial tablet recently placed in one of the halls in the University of Bologna proclaims Carlo Ruini to have been the first to point out the true course of the blood. But a few weeks ago (October, 1876,) there was unveiled in the University of Rome a monument in honor of Andreas Cesalpinus, the great naturalist, for whom the Italian *savans* claim the honor of the great discovery, and now it is proposed to inscribe over the portals of the University of Pisa, in which Cesalpinus was lecturer on medicine, the unkind and unbecoming insinuation, "Ill-advised was the English Harvey, who, in 1628, dared to arrogate to himself the discovery of this mighty truth."

No wonder that rival nations and rival schools should contend for the honor of the discovery of the blood's circulation, for it is the fundamental fact of a rational physiology. It is the keystone of the physiological arch, upon which is reared the vast superstructure of modern medicine.

The circulation of the blood seems to us such a simple fact that we can scarcely realize the struggle which its discovery cost the human intellect. But discoveries usually have long histories. They represent ages of toil and study, of efforts misdirected, and, in fact, oftentimes seem to run through the whole alphabet of failures before their success is spelled out. The accidental experiment with the frog's

thigh in the laboratory of Galvani represents the beginning; the subtle fluid harnessed to gigantic magnets and made to lift prodigious burdens, or as message-bearer mounting the wires and circling the globe, represents the present; between which there runs a long and bitter history of experiment and failure, much the larger portion of which is still unwritten.

So with the circulation. Long years labored at the birth. Erasistratus taught that the arteries were air-tubes. Galen showed them to be filled with blood. Step by step, Vesalius, Servetus, Realdus Columbus, Fabricius, and a host of others, blazed the way for the immortal genius of Harvey. Thus the seed sown in one age ripens into fruit in another age, when the hand of the sower perhaps is dust.

The recorded thoughts of every man are undying. Others appropriate, advance, apply them, and thus many minds are required to secure the immortality of one.

In order to more intelligently trace the birth of the modern theory of the circulation, let us take a rapid survey of the physiology of the pre-Harveian days, so far as it affects the subject under discussion.

One of the most difficult lessons which the human mind has ever had submitted to it was to learn to accept the testimony of the senses. To us, living in the last quarter of the nineteenth century, a century as remarkable for its iconoclastic propensities as for its rapid scientific advancement, this seems hardly credible.

Ancient medicine concerned itself only with the proofs of authority. Modern medicine relies almost wholly upon the proofs of experiment and experience. In the pre-Harveian days no authority was recognized but that which emanated from the oracle of Cos, or the divine apostle of Pergamos, as Hippocrates and Galen were reverentially named. The doctrines of Galen, a man who by his own account was twice called by the god Apollo to study medicine, and of whom the

emperor Marcus Aurelius said, "We have but one physician; Galen is the only man of the faculty," were universally held to be true, and to doubt was medical heresy. An unbroken succession of anatomists for fourteen hundred years studied their dissections through Galenic spectacles, until Vesalius, the bold Fleming, dared assert that Galen's descriptions, drawn from the dissections of monkeys, did not correctly represent human anatomy.

The schooling of Vesalius on the hill of Montfaucon, disputing with dogs and vultures for the bodies of criminals, or at the risk of his life disinterring bodies from cemeteries, was not calculated to increase reverence for the teachings of the past, but gave him that moral courage to burst open the seal of authority which had so long hermetically locked up all medical progress.

The physiology of Galen, which with slight modifications was the doctrine which was taught Harvey at Padua, honored the liver as the central organ of vegetative life.

The liver was the seat of sanguification and the origin of the veins, which were considered the only true blood-vessels, the arteries containing a mixture of spirits and blood. The heart, instead of being the active agent in the distribution of the blood, was a mere cistern; its sole function being the generation of heat and vital spirits.

Three kinds of spirits were recognized: the natural, the vital, and the animal. The natural spirits were located in the liver, the vital in the heart, and the more ambitious animal spirits claimed a residence in the brain.

The prevalent theory of sanguification, then, as summed up by Flourens, is, "the aliment taken into the body was converted into chyle by the stomach and intestines; blood was formed from this chyle in the liver; the vital spirits were exhalations from the blood in the heart, and the animal spirits were elaborated from the vital in the brain. Finally, the blood acquired its temperature from the heart,

and the heart found in the blood, the aliment for its innate heat."

Before this hypothesis of the spirits required a modification of the prevailing belief, it was held that the only motion of the blood was simply that of ebb and flow, "like the tide of Euripus"—the blood in the respective vessels simply passing between the heart and the extremities without intermingling. The hypothesis of the spirits required the intermixture of the two kinds of blood, and Galen, drawing upon the imagination for his facts, wisely announces that the partition between the two sides of the heart is perforated.

What a commentary on the value of human evidence, when a long line of illustrious anatomists, including such as Mondini, who revived human dissection, Barenger de Carpi, and Le Vasseur came forward and confirmed from their own dissections the presence of these openings. In the doctrines so far examined there is but little improvement over that of the Chinese, who believed that the circulation of the radical humors and vital heat began at three o'clock in the morning, reached the lungs in the course of the day, and terminated in the liver at the end of twenty-four hours.

While Galen perpetuated by the weight of his great authority many erroneous views concerning the circulation of the blood, he really inserted the first round in the ladder of discovery when he experimentally proved the arteries to be carriers of blood instead of air, as the etymology of the word indicates.

Our next object must be to close the direct passage between the right and left hearts, the necessity for which communication we have already passed in review; and for this purpose let us call to our assistance Andreas Vesalius. Barengarius first expressed doubts as to the presence of this opening, but it was reserved for Vesalius to boldly announce that the auricular septum is solid, no less so than the rest of the heart,

and that not a single drop of blood can pass through the partition. It seems inconceivable that his master mind did not grasp the pulmonary circulation, upon the border-land of which he now stood, but Vesalius failed to recognize the importance of his discovery. It was reserved for another to light up the true pathway of the blood through the lungs—Michael Servetus. Servetus was born at Villaneuva, in Arragon, in 1557, and though educated for the medical profession, soon became involved in the bitter religious controversies of his time. Strange as it seems, his exposition of the pulmonary circulation is buried under a mass of theological rubbish in a book having for its title "Christianismi Restitutio," where it is stated the blood passes from the right to the left side of the heart by a long and wonderful route through the lungs, where it is agitated and prepared, becomes yellow, and passes from the arterial vein to the venous artery.

We have here not only the pulmonary circulation pointed out, but also foreshadowed the office of the lungs, and the work of that magic artist, oxygen, in painting blue blood with arterial tints. However, when we find Servetus still regarding the liver as the fountain-head of the blood, describing the brain as a cushion for the animal spirits, the nerves as a third class of vessels continued from the arteries, pointing out how the air passes from the nose into the ventricles of the brain, and how the devil takes the same route to the soul, there is abundant reason for skepticism as to the extent and accuracy of his physiological knowledge.

Servetus fell a victim to the intolerance of Calvin, and in 1553 was burnt at Geneva, and every copy of his works was committed to the flames with him. But one copy remains, and it is all scorched and blackened by the fire that burned its author. Is it not significant that the only surviving copy should have belonged to Colladon, one of the accusers of the unfortunate Servetus? There stands the book in the library of the Institute of France, all blackened and charred, with

the very passages underscored upon which Colladon accused Servetus, eloquent in its mute denunciation of the religious intolerance and bigotry of the age which gave it birth.

Although the pulmonary circulation was first suggested by Servetus, it is questionable whether the profession is indebted to him as much as to Realdus Columbus, who independently discovered the same truth six years afterwards. Columbus demonstrated the course of the blood through the lungs by means of vivisections, and taught it from his chair in the University of Padua, and to whom Harvey acknowledges his indebtedness. To him the pulmonary circulation was not a physiological hypothesis to illustrate a theological dogma, but was the logical deduction from anatomical facts.

Very soon Andreas Cesalpinus, the pupil and successor of Columbus, announces for the third time the discovery of the pulmonary circulation, it is claimed, independently of his illustrious teacher, though by this time the doctrine must have been common property. This peripatetic philosopher seems to have been far in advance of his contemporaries in his views of the circulation, and has frequently been credited with a knowledge not only of the pulmonary but also of the systemic circulation. Flourens, in his admirable little work on the discovery of the circulation, gives Cesalpinus the double honor of having been the first to give us a method in science and the first to point out the two circulations. We have already alluded to the recent claims of the Italian physicians, who, not content with erecting a monument to his honor, now propose, in a tablet in the University of Pisa, to brand Harvey before the world as a plagiarist.

Cesalpinus was born in Arezzo, Tuscany, in 1519; resigned the professorship of medicine which he held in the University of Pisa to become physician to Pope Clement VIII., and died at Rome in 1603. He was evidently a man of large learning, and ranked high as a naturalist as well as a physician. He undoubtedly did good service in the work o

discovery, as he was the first to apply the term *circulation* to the movement of the blood, and was acquainted with the important fact that when a vein is tied it fills below and not above the ligature. Skepticism as to his knowledge of the systemic circulation is certainly admissible when we find him ignorant of the valves in the veins, and see him explaining the distal swelling of a vein after the application of a ligature, in the effort of the blood to get back to the heart lest it be cut off and suffocated, and hear him speak of the flux and reflux of the blood. In order to give you a more correct idea of the justness of these recent claims, permit me to quote two passages from the great work of Cesalpinus, "*Questiones Peripateticæ*," for which, as for many other facts herein stated, I am indebted to Dr. S. Gamgee's recent essays in the *London Lancet*:

"In living creatures we see the aliment conducted through the veins to the heart, as though that were the manufactory of innate heat, and it having there attained its ultimate perfection, distributed through the arteries into the whole body by *the action of the spirit (agente spiritu)*, which is produced in the heart out of the same aliment."

Again:

"Since, however, when we are awake the movement of native heat is outwards (that is, to the sensoria), but in sleep inwards (that is, to the heart), we must suppose that when we are awake a quantity of spirit and of blood is carried to the arteries, for from them is the passage to the nerves; but that in sleep the same heat returns to the heart through the veins—not through the arteries—for the natural passage into the heart is afforded by the vena cava, not by the artery. The pulsations are a proof of this; for these, in waking persons, are strong, violent, rapid, and frequent, with a certain vibration, but in sleep are weak, languid, slow, and rare. For in sleep the native heat passes less in the arteries; it forces its way into them with more violence when persons wake up. The veins are, however, just the contrary, for they are more swollen in sleep, but thinner when we awake, as is clear to any one who looks at the veins in the hand. For the native heat passes in sleep from the arteries into the veins through the communion of the mouths, which they call anastomoses, and thence to the heart. As, however, the overflowing of the blood to the higher parts, and its return to the lower parts, like the Euripus, is

manifest in sleep and in wakefulness, so a movement of this kind is perceived without difficulty in whatever part of the body a ligature is employed, or the veins are in any way closed; for where the through passage is denied, the streams swell up in the part where they are accustomed to flow."

We have here no conception of the heart as the cause of the blood's movement. We have again repeated the old error of a union of blood and spirit, and the absurd doctrine taught that the blood and spirit passes from the arteries into the veins only during sleep.

Is this the doctrine of the circulation as taught by Harvey? Is it upon such passages as these that the Italian school propose to placard Harvey as a fraud?

But even if Cesalpinus did comprehend the circulation, did the world learn it from him? As Dr. Gamgee well says:

"The testimony of Gaspard Hofman is conclusive in proving that while Cesalpinus was ending his long life in the serene atmosphere of the Vatican, the busy halls of Padua took little or no heed of the doctrine of the circulation which he had sketched so wonderfully. Born at Gotha in 1572, after studying at Strasbourg and Altdorf, Gaspard Hofman went to Padua in 1602, the self-same year that Harvey left it to return to England. The Nestor, Fabricius ab Aquapendente was still one of the chief personal glories of the Republic of Venice and of the University of Padua. Under him Hofman studied as Harvey and a generation of anatomists had done before him. Yet, when Hofman returned to Neuremberg, where he taught for forty years, he persistently opposed Harvey's doctrine, and was not even converted by the personal demonstrations with which he was honored by the illustrious Englishman. If the teaching of Cesalpinus had made way, if the doctrine of the circulation had been correctly taught in Padua after Harvey left it, and while Hofman studied there, would he not, learned and accomplished as he was, placed the fact on record?"

No, Harvey received all the obloquy which was heaped upon the new theory, and to him alone belongs all the honor.

The next name that we must mention in our chronicle is that of Fabricius ab Aquapendente, one of the best anatomists that the glorious old University of Padua ever had. Fabricius discovered the valves in the veins (1574), and thus

inserted the last round in the ladder of discovery, up which, in the fullness of time, Harvey walked to immortality.

William Harvey was born on the 1st of April, 1578, at Folkstone, in Kent. At nineteen years of age he graduated from Caius Gonvil College, Cambridge, and thus prepared, he enrolled himself as a student of medicine in the University of Padua, then the most famous seat of medical instruction in the world.

In 1602 Harvey returned to London and engaged in the practice of his profession. When only thirty-seven years of age he was chosen to deliver the lectures on anatomy and surgery at the College of Physicians, and in his first course of lectures (1616) taught the circulation of the blood nearly as we know it to-day.

For nine years longer Harvey continued to elaborate and prove his new theory before he gave it to the world in that remarkable treatise, "*Exercitatio Anatomica de Motu Cordis et Sanguinis.*"

Remember that Harvey never saw the circulation, the necessity of which he demonstrated beyond a doubt. It required many years more for the microscope to reveal to Malpighi the wonderful secret of the capillary circulation; and a century and a half must pass before a Priestley unfolds the chemical composition of the air, and thus completes the story of the circulation.

Harvey was intimately associated with the Court of England, first as physician to James I., and subsequently as physician to the unfortunate Charles I., in which capacity we have already met him on the field of Edgehill.

We can not but feel that Harvey was fortunate in the age in which he lived. We have already seen how thoroughly the way had been prepared for his especial work. The discovery of the blood's circulation could not have been much longer delayed. He lived in an age of political, theological, and scientific excitement. He was a direct sufferer by one

of the fiercest struggles between throne and people that the world has ever seen. A Galileo was carrying the torch of regeneration into the dark domain of physics; Kepler was successfully interrogating the planets as to the laws that govern their movements; Cromwell, Shakspeare, Milton, Bacon, Robert Boyle, Dryden, and Ben. Jonson were numbered among his contemporaries.

When Harvey appeared, his mission was to apply, to grasp as a whole. The facts were already in the possession of his contemporaries, but it required the genius of a Harvey to mould them into a unit, to marshal this chaos of facts into the symmetry of a science.

But why detract from Harvey's glory on this account? Is not this the mission of nearly all discoverers? Let us look at the history of vaccination. The loiterer in the little church-yard at Yetminster, England, will there find a tombstone on which is written the following inscription: "Sacred to the memory of Benjamin Jesty, who departed this life on the 16th of April, 1816, aged seventy-nine years. He was born at Yetminster, in this county, and was an upright and honest man, particularly noticed for having been the first person (known) who introduced cow-pox by inoculation, and who, from great strength of mind, made an experiment from the cow on his wife and two sons in the year 1774." All honor to farmer Jesty! But does the recognition of Jesty's part detract in the least from the glory of Jenner, who, twenty-two years afterwards, without any knowledge of the experiment of his fellow countryman, crystalized into a life-saving principle the neglected gossip of the milkmaids of Sodbury and taught it to the world? This was the master-stroke of genius.

The question may arise in your minds, What was there left for Harvey to discover? I answer, in the language of Dr. Rolleston, Harveian orator for 1873, "Nothing less than *the circulation itself*. His predecessors had but impinged, and

that by guess-work, upon different segments of the circle, and then gone off at a tangent into outer darkness, whilst he worked, and proved, and demonstrated round its entire periphery."

Harvey's discovery was a true discovery in every sense of the word. He brought to his aid a large and exact knowledge of anatomy, both human and comparative—a mind thoroughly cultured—an earnestness of purpose and an industry which yield to no difficulties. His teaching was not a mere hypothesis, based upon an isolated fact or two, but was a demonstration complete and perfect as was possible with the then existing state of knowledge.

Harvey had sincere faith in the evidences of his senses; not reason or precedent, but *experiment* was the tribunal to which he constantly appealed, hence he made extensive use of vivisections.

"I propose to teach anatomy," he writes, "not from books, but from dissections." Like Descartes, who, when asked to show his library, took his visitor to an out-house, and pointing to the half dissected bodies of animals and birds, says: "There are my books—this is my library."

Harvey's essay on "The Motion of the Heart and Blood" is the epic poem of medicine. We have no time to enter into an analysis of its contents to-day, but I cordially commend to your careful attention this essay, one of the grandest specimens of inductive reasoning which the world has ever seen.

Fortunately we have an excellent translation of Harvey's works, by Robert Willis, made under the auspices of the Sydenham Society, 1847.

Harvey was particularly fortunate in living to see his doctrines universally accepted and taught, but it required twenty-five years to bring it about. We are told that no physician who was past forty-five years of age when the discovery was announced, ever gave his adherence to it. Gos-

siping John Aubrey tells us that after Harvey's book on the circulation came out "he fell mightily in his practice; it was believed by the vulgar that he was crack-brained, and all of the physicians were against him." The same authority says "that although all of his profession would allow him to be an excellent anatomist, I never heard any that admired his therapeutic way. I know several practitioners in this town that would not have given three-pence for one of his bills (prescriptions), and that a man could not tell by his bills what he did aim at."

The years roll on, and we find this mighty philosopher, as full of years as he is full of honor and glory, like Sir George Ent found him, "Democritus-like, busy with the study of natural things, his countenance cheerful, his mind serene, embracing all within its sphere." Or, as Harvey writes of himself in one of his letters to Mardi, of Florence, "I, myself, though verging on my eightieth year, and sorely failing in bodily strength, nevertheless feel my mind still vigorous, so that I continue to give myself up with the greatest pleasure to studies of this kind."

William Harvey died on the 3d of June, 1657, in the eightieth year of his age; but the name of William Harvey will ever

"Stand like a beacon, throwing light far out
Over the rippling tides of centuries."

